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ZOOLOGICAL RESEARCH CONDUCTED DURING THE 29TH TRIP OF THE EXPEDITIONARY SHIP VITYAZ (USSR)

[Translation]

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The 29th trip of the Vityaz, the last made as part of the plan of the International Geophysical Year, lasted from 5 October 1958 to 14 March 1959 in the northern part of the Pacific Ocean. All work was done north of 20° N, largely in the eastern part of the ocean which had until this time not been studied by Soviet expeditions. In the western part the 29th trip coincided with the courses of previous trips of the Vityaz. Thus, this trip made it possible to compile a single chart of the northern portion of the Pacific Ocean within the limits of an enormous circle described by the North Equatorial, the Kuro Shiwo, the Aleutian and California Currents.

Some 341 oceanographic stations were employed of which approximately 200 saw composite operations (see chart). Plankton and ichthyoplankton catches were made at 182 stations, bottom samples were taken at 49 stations, bottom dredgings at 29, the variable depth Isaacs-Kidd midwater trawl was used at 34 stations. Zooplankton was sampled at depths of up to 500 meters with Juday traps having an opening of 0.1 or 0.5 square meter, depending on the richness of the plankton. At two of the deep-water plankton stations Bogorov-Ross nets were used with openings of 0.5 square meter. Fish were regularly collected at a depth of 1,000 meters with anchovy [?] (Holmes-Ross?) nets and with lights on the surface. For benthonic collections they used the "Ocean-50" dredge with an area of 0.25 square meters and a Sigsby trawl with a 2.5-meter beam. All bottom samples were washed on a No 140 silk sieve.

The amount of zooplankton was very small. In the 0-100 meter layer the total biological material throughout almost the entire region was less than 100 milligrams per cu. meter. Only at 176° W between 40 and 41° N was it more than 500 milligrams per cubic meter through the accumulation of the blue salp Weelia cylindrica. At spots near the shores there was also somewhat more biological material fluctuating between

100 and 400 milligrams per cubic meter. The greatest paucity was found in the area south from 45° N to the Tropic of Cancer between 150° W and the American shore.

Against this background of significant paucity of zooplankton, separate areas of study revealed to us rather marked accumulations of animals highly characteristic of these areas. In many spots between the Aleutians and 45° N we often ran across Parathemisto amphipods which yielded catches of several liters with a surface trawl. And on the surface in the upper 10-20 centimeters of water near the Aleutians we caught copepods of the species Calanus cristatus; this is interesting because in the literature we find indications that this species avoids the surface. In the Gulf of Alaska there were many large sergestid shrimps. In the western portion of our course at 35° N we came across a large number of huge colonies of diverse tropical radiolaria; they also accounted for samples measuring several liters. At the same place we caught echinospira, the larva of gastropods of the family Lamellaridae. Nearer the shores of America at 35° N were many large pyrosomes with shrimps or small fishes of the genus Tetragonurus mixed in. At 25° N and to a somewhat lesser degree at 20° N along the Mexican shore in the surface water and down to 100 meters we observed groups of large orange Pleuroncodes (Galatheidae). At these spots the surface of the sea was sprinkled with them. These accumulations as plankton serve as feeding grounds for tuna.

Immediately adjacent to the Hawaiian Islands many larvae of Stomatopoda and white shrimps were taken at night by lights. West of the Hawaiian Islands the plankton included many species and individuals of larvae and young bottom fauna carried by the Equatorial Current (nemertime larvae, trochophores and nektochetes, larvae of bryozoa, sea urchins and sea stars, tornaria, etc.). Such a quantity of littoral fauna was not found in plankton in other areas.

The distribution of the zooplankton and the main zoogeographical boundaries of pelagic fauna were closely related to the so-called water masses. The Kuro Shiwo Current leaves the Japanese coast at approximately 35° N. At approximately 160° E the water deriving from the Kuro Shiwo Current takes on a latitudinal direction and moves toward the east between 40 and 45° N. It carries a large reserve of heat and is populated with purely tropical zooplankton. The concept has existed that as the tropical water moved eastward it gradually cooled and parallel with this its tropical population gradually was transformed into the population of the cold California Current. It was found, however, that the change in population does not take place gradually at all. At approximately 160° E the water from the Kuro Shiwo mixes with the water from the cold Oya Siwo Current with its boreal population. As a result between 50 and 45° N to the east of this meridian the population changes

abruptly and there we found southern-boreal plankton, strongly united quantitatively and qualitatively. Farther to the south in the less chilly water of the Kuro Shiwo there lives a purely tropical plankton which gradually grows qualitatively richer to the south. This zonality was studied to 150° W. During the entire stretch from 160° E to 150° W where these currents remain latitudinal there is no change in the plankton population.

At approximately 150° W between 40 and 47° N the current ceases to be latitudinal and spreads out in an enormous fan along the American shore, partially to the north and partially to the south. This causes a strong new mixing of waters and an abrupt new change in the population. In the Gulf of Alaska the influence of southern waters is in general quite small and shows only in the upper 100-meter layer of water. There among the boreal plankton we found only a slight admixture of tropical species (tunicates, in particular), which occur in fact as far north as 55° N. As for the waters which turn toward the south, their effect on the population of the northeastern Pacific is very great. There within the California Current hydrological conditions are very complex and the zooplankton which we encountered was mixed tropical and boreal with representatives of other species depending on the relative amount of water of different origin in each area of the basin. Toward the south the boreal species gradually diminish and the tropical species increase but to the east of the Hawaiian Islands the tropical zooplankton is much scarcer than to the west. This paucity is a clear consequence of the admixture of a significant amount of water from the north which renders conditions in the northeastern Pacific unfavorable for many tropical species.

If we cut across the Pacific Ocean along the 40th parallel from Japan to California we find that the latitudinal zones are well defined only in the middle of the ocean in an area equal to half the distance from shore to shore. After leaving the shores of Japan and before reaching the American shore, the currents deviate from a latitudinal direction and as a consequence the zoogeographical boundaries of the pelagic funa cease to be latitudinal. To the west near the shore of Japan and in the center of the ocean, the zone of mixing of boreal and tropical plankton is comparatively narrow. In the east, however, it is enormous and stretches east from the Hawaiian Islands from 45° N to at least the Tropic of Cancer; there are very few endemic animals in it.

East of the Hawaiian Islands the water is inhabited by mixed tropical and boreal plankton even at a depth below 500 meters. We found here the upper deep-water boreal pelagic annelid Poeobius meseres as far as 20° N (according to data from J. MacGowen of the Scripps Institution of Oceanography this species occurs along the American shore to the equator). In the western part of the ocean the boreal species do not penetrate so far.

Ichthyologists of the expedition did work on the bathypelagic fauna, the pelagic fishes of the open seas and the propagation and development of fish. The boreal bathypelagic ichthyofauna includes a total of approximately 70 species and has a southern limit at approximately 40° N. The degree of its endemism and its homogeneity throughout the ocean are quite great. However a number of species are found only in the eastern or only in the western half of the ocean. Some species are numerous only in one half. N. V. Parin has succeeded in relating these features of the occurrence of deep-water fish to concrete hydrological conditions. In the tropics the population is quantitatively poor but the number of species of bathypelagic fauna reaches several hundreds. On the trip we found rare fish (Caulolepis longidens, Opisthoproctus, Zaphotias) and several fish which are apparently new to science.

Among the data obtained on the pelagic surface fish our interest is attracted to the discovery of the saira (Cololabis saira) in the middle of the ocean which refutes the idea held as to its occurrence on both sides of the Pacific. In the middle of the ocean the Vityaz made commercial catches of this fish. N. V. Parin obtained new data on the spawning grounds and the occurrence of young saira in the entire northern portion of the Pacific Ocean as well as the occurrence of little studied flying fishes of the eastern part of the Pacific Ocean. The faunistic boundaries determined on the basis of the occurrence of fish coincide satisfactorily with those for plankton.

During the stop of the Vityaz off the Nanaimo biological station (Vancouver Island) several ratfish Hydrolagus collei were caught by fishing rod. In the open sea in the tropics several catches were made of Pterolamiops longimanus sharks following the ship and the blue shark Prionace glauca with attached suckers (R. remora). We should mention in particular the catch of a very rare dwarf luminescent shark Eupromicrus bispinatus (approximately 15 centimeters long). Three catches were also made of the snake mackerel (Gempylus serpens). Once in the tentacles of a large squid we found a rare fish Pteraclis sp.

In the boreal region we caught large numbers of young rock trout (Hexagrammidae), Bathymaster species and rockfish (Sebastodes sp.). In the tropics we caught young coryphenes (Coryphaena hippurus along the shores and C.equisetis both along the shore and in the ocean), sunfish (Molidae) at 20° N west of the Hawaiian Islands, porcupine fish (Diodon), and trunkfish (Lactoria diaphana). Young pilot fish (Naucrates ductor) and Nomes albula usually hide among the tentacles of siphonophores (Physalia). Considerable material was collected on the roe, fry and larvae of the deep-water fish; among them were the stylophthalmate larvae of the idiacanths (so-called Stylophthalmus) and leptocephali of eels.

In the boreal region there were always many black-footed albatrosses (Diomedea nigripes) and somewhat fewer Laysan albatrosses (D. immutabilis). Near the shores and throughout the Gulf of Alaska were many gulls and at Vancouver Island divers. Beyond the limits of the boreal region (subarctic water mass) the Laysan albatross is not found while the black-footed albatross decreases in number. Along the Mexican shore phaetons were encountered. East of Hawaii there were no birds far from the shores.

The principal problem of a benthonic nature is the collection of material on the composition and quantitative distribution of the bottom fauna in the northeastern part of the Pacific Ocean, which has been only slightly studied from this angle. Before the operations of the Vityaz small collections of deep-water fauna had been made at several stations of the "Challenger" and somewhat more by expeditions on the "Albatross." Trawlings on the 29th trip had the following disposition with relation to depth: three less than 2000 meters; two from 2000 to 3000 meters; four from 3000 to 4000 meters; nine from 4000 to 5000 meters; nine from 5000 to 6000 meters; and two more than 6000 meters. A single trawling occurred in the eastern part of the Aleutian Trench at a depth of 6270 meters. The quantitative distribution of the bottom fauna in the northern part of the Pacific Ocean is quite uniform and closely related to a number of conditions, and principally to the amount of food on the bottom and the general circulation of the water which has an effect both on supplying the bottom waters with organic remains and oxygen and on the transportation and distribution of the larval stages of a number of bottom animals. Judging from available data the entire northeastern part of the Pacific Ocean studied during this trip is characterized by a lower quantity of bottom fauna than the northwestern part. The bottom seems particularly poor in this respect in the abysses between the California and Mexican shores on the east and the Hawaiian Islands on the west. This is probably the only area in the Pacific Ocean where the abyssal depths of 3000-4000 meters reach right up to the American shores and the continental shelf is so narrow and steep that stations located 50-60 miles from the shore still showed a depth of 3500 meters. These regions of deep bottoms have a very sparse bottom fauna where the total biological material does not exceed 0.05 grams per square meter. The northern boundary of this sparse zone is the beginning of great plain located north of 40° N where the quantity of bottom fauna gradually increases toward the north starting from 0.5-0.8 gram per square meter and reaching 1 gram per square meter in the region of the Gulf of Alaska.

In the southeastern part of the area on the slope along the shores of Southern California and Mexico the bathic bottom fauna quickly increases to 10 and then to 30-50 grams per square meter with a parallel increase in the variety of its composition. Here at depths of approximately 1500-2000 meters we have the very rich bottom fauna of the

California type with an admixture of forms of more southerly origin. Apparently this is furthered by the presence of local littoral branches of the bottom currents which bring abundant food from the shallow zone along the shore. However with the rapid increase in depth due to the steepness of the slope and narrowness of the shelf the effect of the shore currents on the fauna of the open sea diminishes. In addition, the presence of a number of shallow trenches running along the shelf and the slope parallel to the shore acts as a trap for the detritus carried from the shore where it apparently settles without reaching the abyssal region of the open parts of the ocean. Due to the general dryness of the climate in the vicinity of Mexico and Southern California the shore runoff is here generally rather small. All this together has an extremely unfavorable effect on the development of the deep-water bottom fauna and the quantity of biological material here is almost the least for the entire zone of the Pacific Ocean lying relatively close to the shore.

The northeastern part of the ocean north of 40° N right up to the Gulf of Alaska has quite another character with regard to the quantitative distribution of the benthonic fauna. The bottom of this hilly and only slightly divided plain has much more favorable conditions and the amount of benthonic material fluctuates between 0.5 and 1 gram per square meter. The effect of the copious continental runoff from Canada and the effect of the waters of the Bering Sea have a great effect in providing foodstuffs for the deep-sea benthonic fauna of this area.

Of considerable interest for the quantitative distribution of the benthonic fauna are the data obtained from a latitudinal cross section made by the Vityaz in the southernmost part of this area under study. The cross section reached from the Mexican shore to the Hawaiian Islands along the line 20° N and later along 24° as far as 154° E, i.e., through the open portion of the tropical abyssal area of the Pacific Ocean far away from the effect of waters of the continental runoff. The total benthonic fauna at depths of approximately 5000 meters was very low and regular, fluctuating from 20 to 50 milligrams per square meter, made up largely of microfauna and the smaller forms of macrofauna (mollusks, polychaetes, amphipods, and isopods).

Among the numerous finds of faunal interest we must mention first of all the pogonophores discovered for this first time in the Pacific shore region of North America during this trip of the Vityaz. The pogonophores were observed at five Vityaz stations, starting from Queen Charlotte Island (depth 2607 meters) as far as 20° N along the Mexican shore (depth 3340 meters). The least depth at which they were found was 132 meters at Vancouver Island at the beginning of the Strait of Juan de Fuco. Along the Oregon (depth 1375 meters) and Mexican shore we found pogonophores in very hard strong dark tubes up to 20 centimeters long. This material is now being processed by A. V. Ivanov.

During the stays of the Vityaz at Vancouver, San Francisco and Honolulu, participants in the expedition became acquainted with several marine research institutions; conferences were arranged aboard ship (in which foreign scientists participated) with reports on the work of the Vityaz.

At the University of British Columbia in Vancouver, marine biological studies are dealing with plankton and benthos but are not greatly advanced. The Research Council of British Columbia is doing successful work in controlling the shipworm Bankia setacea with sodium arsenite. The principal objects of protection are the sea rafts and timber at the mouths of rivers where the rafts are made up. The Vancouver City Aquarium is large, well-arranged and contains many rare, exotic and interesting fishes (for example, Protopterus, Polypterus, Lepidosteus, chimaeras) and large sea turtles. The biological station at Nanaimo (located on Vancouver Island) resembles mainly our own All-Union Institute of Fishery and Oceanographic Research in the type of work being done. The station has 10 laboratories and a staff of 140 persons. The principal object of research is salmon, both in the open sea and during their migration to the spawning grounds. Studies on other fish and invertebrates is of secondary importance. The biological station has the right to close establishments discharging waste harmful to the salmon and this right is employed. Of the fifty species which are parasitic on the red salmon four have been found to be associated only with the Asiatic or only with the American race. At Nanaimo they are employed to distinguish the races. At the California Academy of Science in San Francisco, work is being done largely on modern and fossil mollusks and on microscopic fossils. The Academy of Science administers the Steinhart Aquarium which is not inferior to that in Vancouver as well as a museum with a large repository and an "African Room" in which large displays photographically reproduce panoramas with animals in their natural surroundings. The background is so skillfully designed that it is impossible to distinguish where the mounted specimens and the foreground end and the background starts. At Stanford University and the Vanderbilt Foundation located on its campus, a vigorous group of marine ichthyologists, mainly taxonomists, is at work. Forty miles north of San Francisco is the biological station of Dillon Beach belonging to the Christian College of the Pacific. Undergraduate and graduate students practice there and are doing some research work.

Ten members of the expedition, including the authors of this article, had an opportunity to fly from San Francisco to the Scripps Institution of Oceanography located near the Mexican border 16 miles north of San Diego. This is a complex institution with a preponderance of biological studies. The institution has a staff of 600 persons, several large buildings and seven ships; research is done and graduates are trained in oceanology and hydrobiology. The budget is five million dollars.

Among the biological studies being done by the Scripps Institution the following are the most interesting. The laboratory of marine genetics is studying the genetics of marine animals and plankton algae in connection with the effect of various substances. The microbiological laboratory is studying the physiology of deep-water bacteria and the role of bacteria as a geochemical factor. The laboratory has thermostatically controlled rooms, sterile rooms for culture seedings, boxes for dosed light and a high-pressure apparatus where deep-water bacteria collected on the "Galathea" have been living for seven years.

The laboratory of invertebrate zoology studies a wide range of problems on systematics, life cycles, ecology and population counts. The predominant work is on plankton in which a study is made of the relation of its distribution to hydrological conditions. At present all the main groups of plankton are being assigned to graduates as dissertation topics in order to have monographs on systematic and ecology. As a rule the authors of these works are distinguished for a good knowledge of hydrology. There is also a laboratory of marine vertebrates which studies mainly fish. Extensive composite studies are being made of tuna. The laboratory is well equipped with modern apparatus; all the marine institutions in the USA and Canada which we visited take their lead from the methods used at the Scripps Institution.

In Honolulu (Oahu) we visited the Marine Laboratory of Hawaii University and the Pacific Research Institute of Marine Fisheries which belongs to the US Fish and Wildlife Service and corresponds in scope to our All-Union Institute of Fishery and Oceanographic Research. The marine laboratory is located on a coral island alongside the island of Oahu. There are 40 species of coral living on the reefs there. The laboratory is doing work on the absorption of radioisotopes by marine animals (principally the fish Tilapia), on fish which are poisonous for food (tested principally on mongooses), on fisheries and termites. At the Fishing Institute the main research object is the tuna and its young. Other studies are being done on zooplankton. The American zooplankton specialists both on the mainland and in Hawaii are at present spending a lot of energy in modernizing the taxonomy of the copepods which is in a chaotic state. The Honolulu Aquarium belongs to the University and has many coral and fresh-water tropical fish.

FIGURE APPENDIX

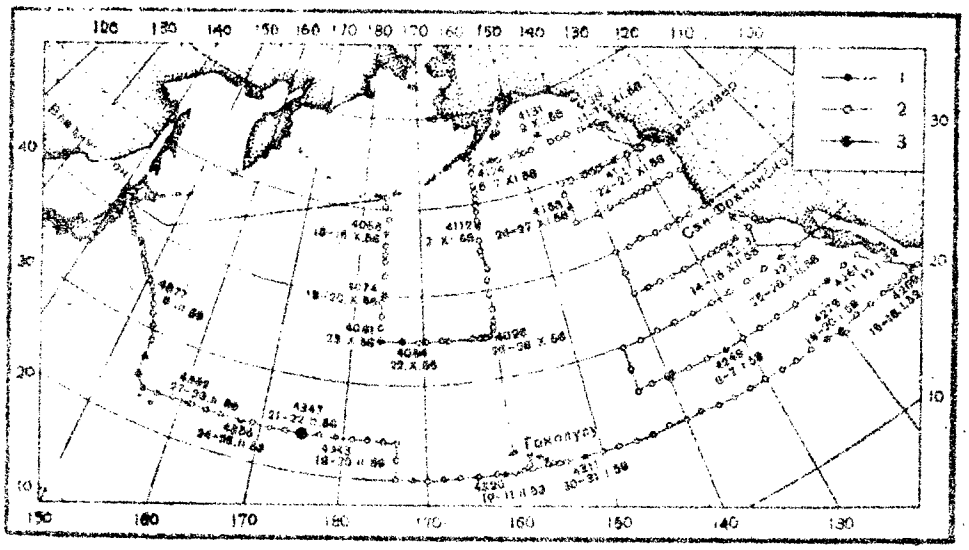

Figure 1
Course of the 29th trip of the Vityaz, 5 October 1958 to 14 March 1959.
Dots mark oceanographic station sites.

1 - stations where independent anchor buoy stations were located with deep water current recorders;

2 - stations where composite operations were carried out;

3 - sites of deep water plankton catches.

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